FORM 2

THE PATENTS ACT, 1970
(39 of 1970)
AND
THE PATENTS RULES, 2003

COMPLETE SPECIFICATION

(See section 10; rule 13)

TITLE OF THE INVENTION

"METHOD FOR GENERATING MODULATION SIGNALS FOR A SATELLITE NAVIGATION SYSTEM"

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The following specification particularly describes
the invention and the manner
in which it is to be performed

METHOD FOR GENERATING MODULATION SIGNALS FOR A SATELLITE NAVIGATION SYSTEM

FIELD OF THE INVENTION

The present invention relates to the field of generating a spreading Synthesized Binary Offset Carrier (SBOC) modulation signal for a satellite navigation system. The present invention specifically relates to the field of method of generating the generating SBOC modulation signalfor a direct sequence spread spectrum (DSSS) signals on a navigation satellite system.

BACKGROUND OF THE INVENTION

Global Navigation Satellite System (GNSS) uses common frequency band for transmission of signals. GNSS satellites transmit DSSS signals. All GNSS service providers transmit interoperable and compatible signals for open and restricted services. At present, many GNSS service providers are planning to provide common open civilian service in L1 (1575.42 MHz) frequency band. Hence, it is mandatory to transmit interoperable and compatible signals from different GNSS constellation. To meet this requirement, common power spectral density (PSD) for open civilian service signals is defined in-view of the benefits to the common civilian users in L1 frequency band.

Multiplexed Binary Offset Carrier (MBOC) modulation scheme is recommended by GNSS service providers. PSD of the MBOC(6, 1, 1/11) modulated signal is given in equation (1). It shows the two Binary Offset Carrier (BOC) components having 1 MHz and 6 MHz subcarrier frequency respectively with 1Mcps code rate in each component.

$$PSD: G_{MBOC(6,1,1/11)}(f) = \frac{10}{11} G_{BOC(1,1)}(f) + \frac{1}{11} G_{BOC(6,1)}(f) \quad (1)$$

where, $G_{BOC(1,1)}(f)$ is PSD of BOC(1, 1) modulation signal,$G_{BOC(6,1)}(f)$ is PSD of BOC(6, 1) modulation signal and $G_{MBOC(6,1,1/11)}(f)$ is the PSD of the MBOC(6, 1, 1/11) modulation signal. Thus, it is necessary to meet the above PSD requirements by all GNSS service providers to provide common open civilian service in L1 frequency band. But, common spectrum does not require to transmit identical waveforms from the GNSS satellites.

US20100284440A1 presents time multiplexed binary offset carrier (TMBOC) modulation DSSS signals for satellite navigation system. In this case, modulated signal

consists of data and pilot signals. Data signal is generated using the single spreading symbol whereas pilot signal is generated by time multiplexing of two different spreading symbols. Spreading symbol of data signal is same as a one of the spreading symbol of pilot signal. The presented modulated signal meets the MBOC PSD requirement presented in equation (1).

EP2482479A1 presents composite binary offset carrier (CBOC) spreading modulation signals for satellite navigation system. In this case, CBOC waveform is generated from first and second BOC waveforms, the waveform having predetermined PSD comprising at least reduced cross spectral terms of the PSDs of the first and second BOC waveforms averaged over at least two predetermined time intervals. Method also comprises the steps of arranging for the states of the first and second BOC signals over a subsequent predetermined time interval of the at least two predetermined time intervals to be complementary to the states of the first and second BOC signals over a current predetermined time interval of the at least two predetermined time intervals. The presented CBOC modulated signal meets the MBOC PSD requirement presented in equation (1). Here, the resulting modulation signal waveform is having 4 levels of amplitude which is a non-constant modulation signal. This modulation scheme suffers from the distortion added by the onboard satellite high power amplifier system due to non-constant envelope. Hence, the onboard satellite high power amplifier system has to be operated in linear region to avoid any distortion in the modulated signal. Thus, transmitting only CBOC signal from the navigation satellite is not an efficient modulation scheme. If CBOC modulation signal is to be used in navigation satellites, then other open/restricted services signals have to be combined on the same frequency bandif available along with Interplex modulation signal to convert it intoa constant envelope signal. The resultant modulation signal contains additional Interplex modulation signal which needs to be further analysed in-terms of interoperability and compatibility with other GNSS signals in the same frequency band. Further, there is no flexibility in allocating power sharing between data and pilot channel other than 50% power sharing between data and pilot channel while meeting the MBOC PSD requirement.

BeiDou Navigation Satellite System BDS-SIS-ICD-B1C-1.0 Interface Control Document (ICD) presents the Quadrature Multiplexed Binary Offset Carrier (QMBOC) modulation scheme. In this case, modulated signal consists of data and pilot signals. Data signal is generated using the single spreading symbol whereas pilot signal is generated by

quadrature multiplexing of two different spreading symbols. Spreading symbol of data signal is same as a one of the spreading symbol of pilot signal. The presented modulated signal meets the MBOC PSD requirement presented in equation (1). But, the QMBOC modulation waveform is a non-constant envelope. Similarly, this modulation scheme also suffers from the distortion added by the onboard satellite high power amplifier system as the CBOC modulation signal. Hence, the onboard satellite high power amplifier system has to be operated in linear region to avoid any distortion in the modulated signal. Thus, transmitting MBOC signal from the navigation satellite is not an efficient modulation scheme in-terms of onboard satellite implementation aspects.

Accordingly, in order to overcome the one or more aforesaid limitations, the present invention discloses a method to provide Synthesized Binary Offset Carrier (SBOC) modulation signal generation which generates constant envelope modulated signal while maintaining the MBOC PSD levels. It also provides the flexibility in allocating the power sharing between data and pilot signals. SBOC modulation signal generation method uses quadrature multiplexing of data and pilot signals. Data and pilot signals consist of two different BOC components. One of the BOC components of data or pilot signals is generated by multiplexing of the other available three BOC components of data and pilot signals. A modulated signal is synthesized by adding all four components in different amplitudes and phases. Amplitudes and phases of each of the four individual BOC components are selected to generate the constant envelope signal while meeting MBOC PSD level requirements.

OBJECT OF THE INVENTION

An object of the invention is to generate the modulation signal for navigation satellite system using quadrature multiplexing of data and pilot signals having two different BOC components in each signal which meets MBOC PSD requirements.

Another object of the invention is to generate the constant envelope modulation signal for satellite navigation system which generates one of the BOC components of data or pilot signals by multiplexing of other BOC component of the same signal and two BOC components of the other signal. The generated multiplexed signal is a useful component of data or pilot signal which is used as a desired MBOC component.

Yet another object of the invention is to generate the constant envelope modulation signal for satellite navigation system using quadrature multiplexing of the data and pilot

signals having two different BOC components which are generated independently from each other while maintaining the MBOC PSD level.

Yet another object of the invention is to provide the flexibility of providing the power sharing of data and pilot signals by varying the amplitude and phase state of each BOC components of data and pilot signals while maintaining MBOC PSD level and constant envelope waveform. Flexibility in allocating power levels of individual components provides possibility of optimizing the performance of modulation signal.

Yet another object of the invention is to generate one of the BOC components of the data or pilot signals by multiplexing of other BOC component of the same signal and two BOC components of the other signal. To generate the useful BOC component through the multiplexing process requires maintaining time synchronization between available three BOC components. Perfect time synchronization between available three BOC components and generated useful BOC component ensures in generating constant envelope modulation signal at the transmitter end.

SUMMARY OF THE INVENTION

Provided is a method and apparatus to provide Synthesized Binary Offset Carrier (SBOC) modulation signal generation which generates constant envelope modulated signal while maintaining the MBOC PSD levels.

Additional aspects will be set forth in part in the description which follows and, in part, will be apparent from the description, or may be learned by practice of the presented embodiments.

According to an aspect of the present inventive concept, a method of generating the modulation signal consists of two signals which are quadrature multiplexed to generate constant modulus signal while maintaining the MBOC(6, 1, 1/11) modulation signal PSD levels. Each signals are consisting of the two different BOC components. Hence, generated modulated signal contains the four BOC components. One of the BOC components of data or pilot signals is uniquely derived from the other component of same signal and two components of other signal. Synthesizing all the four components of both signals in various proportions of amplitude and phase states results in modulated signal that has constant modulus. Constant modulus signal provides performance advantage in transmitting signal from the navigation payload.

Furthermore, to generate BOC component which is a desired component of data or pilot signals using available other BOC component of same signal and two BOC components of other signals requires perfect time synchronization between all the available BOC components at the signal generation end. The time synchronization also ensures the generation of constant modulus signal. Hence, uniquely generated desired BOC component ensures the generation of SBOC modulation signal which meets MBOC(6, 1, 1/11) PSD requirement and constant modulus signal.

According to another aspect of the present inventive concept, SBOC modulation signal generation method provides the flexibility in providing the power sharing of the individual components of each signals while meeting MBOC(6, 1, 1/11) PSD requirement and constant modulus signal. Flexibility in allocating power levels of individual components provides possibility of optimizing the performance of modulation signal.

According to another aspect of the present inventive concept, a method of generating the modulation signal consists of two signals which are quadrature multiplexed to generate constant modulus signal while maintaining the MBOC(6, 1, 1/11) modulation signal PSD levels. Each signals are consisting of the two different BOC components. Hence, generated SBOC signal contains the four BOC components. SBOC modulated signal is generated from the available BOC components of both signals assuming perfect time synchronization between available BOC components. Synthesizing all the four components of both signals in various proportions of amplitude and phase states results in modulated signal that has constant modulus.

According to another aspect of the present inventive concept, a method of generating a spreading Synthesized Binary Offset Carrier (SBOC) modulated signal is disclosed. The method comprising: generating first and second signal using first and second signal generators, modulating first and second generated signals with signal generated from at least a subcarrier generators. Further, generating multiplexed modulated signal, wherein said generation is based on multiplexing of sub modulated signals generated from modulating first signal generator and the second signal generator with at least one subcarrier generator. Furthermore, synthesizing the multiplexed modulated signal and sub modulated signals using a unit to generate SBOC modulated signal.

According to another aspect of the present inventive concept, a system for generating a spreading Synthesized Binary Offset Carrier (SBOC) modulated signal. The system

comprises: a first signal generator for generating first signal, a second signal generator for generating second signal. Further, the system also comprising at least a subcarrier generator connected with the signal generated from the first signal generator or the second signal generator, configured to modulate the first generated signal and the second generated signal. Furthermore, plurality of electrical units configured to generate multiplexed modulated signal, wherein said generation is based on multiplexing of sub modulated signals generated from modulating first signal generator and the second signal generator with signal generated from at least one subcarrier generator. Moreover, a unit is used for synthesizing the multiplexed modulated signal and sub modulated signals to generate SBOC modulated signal.

BRIEF DESCRIPTION OF THE DRAWINGS

To further clarify advantages and aspects of the invention, a more particular description of the invention will be rendered by reference to specific embodiments thereof, which is illustrated in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail with the accompanying drawings, which are listed below for quick reference.

FIG. 1 shows the synthesized binary offset carrier (SBOC) modulation generation method by generating the desired BOC component of the data signal using available other BOC component of data signal and two BOC components of the pilot signal and synthesizing data and pilot BOC components for satellite navigation system, in accordance with an exemplary embodiment of the present invention;

FIG. 2 shows the SBOC modulation generation method by generating the desired BOC component of the data signal using available other BOC component of data signal and two BOC components of the pilot signal and adding all BOC components of data and pilot signals with different amplitude and phase to meet the MBOC PSD while maintaining the constant modulus signal for satellite navigation system, in accordance with an exemplary embodiment of the present invention;

FIG. 3 shows the SBOC modulation generation method by generating all the BOC components of data and pilot signals independently and adding all BOC components of data and pilot signals with different amplitude and phase to meet the MBOC PSD while

maintaining the constant modulus signal for satellite navigation system, in accordance with an exemplary embodiment of the present invention;

FIG. 4 shows the satellite navigation receiver architecture for tracking and decoding the SBOC modulated signal transmitted from satellite using SBOC modulated signal generator at the receiver end, in accordance with an exemplary embodiment of the present invention;

FIG. 5 shows the example waveform of modulated navigation encoded data bits used in generating the two BOC components of data signal for generating the SBOC modulated signal, in accordance with an exemplary embodiment of the present invention;

FIG. 6 shows the example waveform of modulated ranging code chips used in generating the BOC components of pilot signal for generating the SBOC modulated signal, in accordance with an exemplary embodiment of the present invention;

FIG. 7 shows the example waveform of modulated ranging code chips used in generating the BOC components of data signal for generating the SBOC modulated signal, in accordance with an exemplary embodiment of the present invention;

FIG. 8 shows the example waveform of subcarrier of BOC(m_1, m_2) modulated data signal and BOC(m_1, m_4) modulated pilot signal for generating the SBOC modulated signal, in accordance with an exemplary embodiment of the present invention;

FIG. 9 shows the example waveform of subcarrier of BOC(m_3, m_2) modulated data signal and BOC(m_3, m_4)modulated pilot signal for generating the SBOC modulated signal, in accordance with an exemplary embodiment of the present invention;

FIG. 10 shows the example waveforms of BOC(1, 1) and BOC(6, 1) modulated components of pilot signal, BOC(1, 1) modulated component of data signal and multiplexed component which is a desired BOC(6, 1) modulated component of data signal for generating the SBOC modulated signal, in accordance with an exemplary embodiment of the present invention;

FIG. 11 shows the example constellation of constant envelope SBOC modulated signal which meets the MBOC PSD levels, in accordance with an exemplary embodiment of the present invention;

FIG. 12 shows the PSD levels of the constant modulus SBOC modulated signal which meets the MBOC PSD levels, in accordance with an exemplary embodiment of the present invention;

FIG. 13 shows the comparison of autocorrelation of SBOC modulation signal with other MBOC modulations like TMBOC and CBOC, in accordance with an exemplary embodiment of the present invention;

FIG. 14 shows the comparison of multipath error envelope for non-coherent early-late processing (NELP) of SBOC modulation signal with other MBOC modulations like TMBOC and CBOC, in accordance with an exemplary embodiment of the present invention.

It may be noted that to the extent possible, like reference numerals have been used to represent like elements in the drawings. Further, those of ordinary skill in the art will appreciate that elements in the drawings are illustrated for simplicity and may not have been necessarily drawn to scale. For example, the dimensions of some of the elements in the drawings may be exaggerated relative to other elements to help to improve understanding of aspects of the invention. Furthermore, the one or more elements may have been represented in the drawings by conventional symbols, and the drawings may show only those specific details that are pertinent to understanding the embodiments of the invention so as not to obscure the drawings with details that will be readily apparent to those of ordinary skill in the art having benefit of the description herein.

DETAILED DESCRIPTION OF THE INVENTION

It should be understood at the outset that although illustrative implementations of the embodiments of the present disclosure are illustrated below, the present invention may be implemented using any number of techniques, whether currently known or in existence.

The exemplary embodiments described herein detail for illustrative purposes are subject to many variations in the structure and design. It should be emphasized, however, that the present invention is not limited to a method of generating a spreading SBOC modulation signal as described herein. It is understood that various omissions and substitutions of equivalents are contemplated as circumstances may suggest or render expedient, but these are intended to cover the application or implementation without departing from the spirit or scope of the claims of the present invention. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

The term “some” as used herein is defined as “none, or one, or more than one, or all.” Accordingly, the terms “none,” “one,” “more than one,” “more than one, but not all” or

“all” would all fall under the definition of “some.” The term “some embodiments” may refer to no embodiments or to one embodiment or to several embodiments or to all embodiments.

Accordingly, the term “some embodiments” is defined as meaning “no embodiment, or one embodiment, or more than one embodiment, or all embodiments.” The terminology and structure employed herein is for describing, teaching and illuminating some embodiments and their specific features and elements and does not limit, restrict or reduce the spirit and scope of the claims or their equivalents.

More specifically, any terms used herein such as but not limited to “includes,” “comprises,” “has,” “consists,” and grammatical variants thereof do NOT specify an exact limitation or restriction and certainly do NOT exclude the possible addition of one or more features or elements, unless otherwise stated, and furthermore must NOT be taken to exclude the possible removal of one or more of the listed features and elements, unless otherwise stated with the limiting language “MUST comprise” or “NEEDS TO include.”

Whether or not a certain feature or element was limited to being used only once, either way it may still be referred to as “one or more features” or “one or more elements” or “at least one feature” or “at least one element.” Furthermore, the use of the terms “one or more” or “at least one” feature or element do NOT preclude there being none of that feature or element, unless otherwise specified by limiting language such as “there NEEDS to be one or more . . . ” or “one or more element is REQUIRED.”

Unless otherwise defined, all terms, and especially any technical and/or scientific terms, used herein may be taken to have the same meaning as commonly understood by one having an ordinary skill in the art.

Reference is made herein to some “embodiments.” It should be understood that an embodiment is an example of a possible implementation of any features and/or elements presented in the attached claims. Some embodiments have been described for the purpose of illuminating one or more of the potential ways in which the specific features and/or elements of the attached claims fulfill the requirements of uniqueness, utility and non-obviousness.

Use of the phrases and/or terms such as but not limited to “a first embodiment,” “a further embodiment,” “an alternate embodiment,” “one embodiment,” “an embodiment,” “multiple embodiments,” “some embodiments,” “other embodiments,” “further

embodiment", "furthermore embodiment", "additional embodiment" or variants thereof do NOT necessarily refer to the same embodiments. Unless otherwise specified, one or more particular features and/or elements described in connection with one or more embodiments may be found in one embodiment, or may be found in more than one embodiment, or may be found in all embodiments, or may be found in no embodiments. Although one or more features and/or elements may be described herein in the context of only a single embodiment, or alternatively in the context of more than one embodiment, or further alternatively in the context of all embodiments, the features and/or elements may instead be provided separately or in any appropriate combination or not at all. Conversely, any features and/or elements described in the context of separate embodiments may alternatively be realized as existing together in the context of a single embodiment.

The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatus to perform the methods described herein. The structure for a variety of these systems is apparent from the description above. In addition, the exemplary embodiment is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the exemplary embodiment as described herein.

A machine-readable medium (memory) includes any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). For instance, a machine-readable medium includes read only memory ("ROM"); random access memory ("RAM"); magnetic disk storage media; optical storage media; flash memory devices; and electrical, optical, acoustical or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.), just to mention a few examples.

Some portions of the detailed description herein are presented in terms of algorithms and symbolic representations of operations on data bits performed by conventional computer components, including a central processing unit (CPU), memory storage devices for the CPU, and connected display devices. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is generally perceived as a self-consistent sequence of steps leading to a desired result. The

steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be understood, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise, as apparent from the discussion herein, it is appreciated that throughout the description, discussions utilizing terms such as “processing” or “computing” or “calculating” or determining or “displaying” or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

It is fundamental to the electrical engineering and software engineering arts that functionality that can be implemented by loading executable software into a computer can be converted to a hardware implementation by well-known design rules. Decisions between implementing a concept in software versus hardware typically hinge on considerations of stability of the design and numbers of units to be produced rather than any issues involved in translating from the software domain to the hardware domain. Generally, a design that is still subject to frequent change may be preferred to be implemented in software, because re-spinning a hardware implementation is more expensive than re-spinning a software design. Generally, a design that is stable that will be produced in large volume may be preferred to be implemented in hardware, for example in an application specific integrated circuit (ASIC), because for large production runs the hardware implementation may be less expensive than the software implementation. Often a design may be developed and tested in a software form and later transformed, by well-known design rules, to an equivalent hardware implementation in an application specific integrated circuit that hardwires the instructions of the software. In the same manner as a machine controlled by a new ASIC is a particular machine or apparatus, likewise a computer that has been programmed and/or loaded with executable instructions may be viewed as a particular machine or apparatus.

Referring to the FIG. 1, the synthesized binary offset carrier (SBOC) modulation generation method by generating the desired BOC component of the data signal using available other BOC component of data signal and two BOC components of the pilot signal and synthesizing BOC components of data and pilot signals for spread spectrum satellite based navigation system, in accordance with an exemplary embodiment of the present invention. Data signal contains BOC(m1, m2) and BOC(m3, m2) modulation components and pilot signal contains BOC(m1, m4) and BOC(m3, m4) modulation components. The SBOC modulation generation method provides the way of generating the constant modulus signal using the data and pilot signals. The methodology also provides the flexibility in allocating the power sharing of each BOC components of data and pilot signals while maintaining the constant modulus signal.

The SBOC modulation signal contains the data and pilot spread spectrum modulated signals. Data bits (10) are given to encoder (11) before it is spreaded by multiplying (13) encoded data bits with the output of data channel ranging code generator (12). Output of the data channel ranging code generator (12) is a modulated ranging code with chip rate of m_2*1.023 Mcps. Where, m_2 is an integer number with m_2>0. The spreaded data signal is multiplied (15) by the output of BOC(m_1, m_2) subcarrier generator (14)to generate the BOC(m_1, m_2) modulated data signal (23). The subcarrier frequency of BOC(m_1, m_2) modulation is m_1*1.023 MHz.Where, m_1 is an integer number with m_1>0. Output of pilot signal ranging code generator (16) is a modulated ranging code with chip rate of m_4*1.023 Mcps. Where, m_4 is an integer number with m_4>0. Pilot signal ranging code is multiplied (18) by the output of the BOC(m_1, m_4) subcarrier generator (17) to generate the BOC(m_1, m_4) modulated pilot signal (25). Pilot signal ranging code is also multiplied (20) by the output of the BOC(m_3, m_4) subcarrier generator (19) to generate the BOC(m_3, m_4) modulated pilot signal (26).The subcarrier frequency of BOC(m_3, m_4) modulation is m_3*1.023 MHz. Where, m_3 is an integer number with m_3>0. BOC(m_1, m_2) modulated data signal (23), BOC(m_1, m_4) modulated pilot signal (25) and BOC(m_3, m_4) modulated pilot signal (26) are multiplied (21) to generate multiplexed component (24). The generated multiplexed component (24) is a desired useful BOC(m_3, m_2) modulated data signal which is used for generating the SBOC modulation signal. BOC(m_1, m_2) modulated data signal (23), BOC(m_3, m_2) modulated data signal (24), BOC(m_1, m_4) modulated pilot signal (25) and BOC(m_3, m_4) modulated pilot signal

(26) are multiplexed to generate the SBOC modulation signal (27).BOC(m_1, m_2) modulated data signal (23) is represented by $S_{d,a}(t)$ which is given as,

$$S_{d,a}(t) = C_d(t)d(t)SC_{d,a}(t) \quad (2)$$

Where, $C_d(t)$ is data channel spreading code sequence which is represented as,

$$C_d(t) = \sum_{k=-\infty}^{k=\infty} g_k(t - kT_{C1}) \quad (3)$$

where, $g_k(t - kT_{C1})$ are a series spreading symbols.$T_{C1}$is a period of a spreading symbol which is computed as $T_{C1}(\text{sec}) = 1/(m_2 * 1.023 * 10^6)$. $d(t)$is an encoded data sequence. $SC_{d,a}(t)$is a subcarrier which is represented as,

$$SC_{d,a}(t) = sgn\big(\sin\big(2\pi f_{d,a}t\big)\big) \quad (4)$$

where, $f_{d,a}$ is a subcarrier frequency which is computed as$f_{d,a}(Hz) = m_1 * 1.023 * 10^6$.

BOC(m_1, m_4) modulated pilot signal (25) is represented by $S_{p,a}(t)$ which is given as,

$$S_{p,a}(t) = C_p(t)SC_{p,a}(t) \quad (5)$$

where, $C_p(t)$ is pilot channel spreading code sequence including primary and secondary overlay code which is represented as,

$$C_p(t) = \sum_{k=-\infty}^{k=\infty} y_k(t - kT_{C2}) \quad (6)$$

where, $y_k(t - kT_{C2})$ are a series spreading symbols including the secondary overlay code. $T_{C2}$is a period of a spreading symbol which is computed as $T_{C2}(\text{sec}) = 1/(m_4 * 1.023 * 10^6)$. $SC_{p,a}(t)$is a subcarrier which is represented as,

$$SC_{p,a}(t) = sgn\big(\sin\big(2\pi f_{p,a}t\big)\big) \quad (7)$$

where, $f_{p,a}$ is a subcarrier frequency which is computed as $f_{p,a}(Hz) = m_1 * 1.023 * 10^6$.

BOC(m_3, m_4) modulated pilot signal (26) is represented by $S_{p,b}(t)$ which is given as,

$$S_{p,b}(t) = C_p(t)SC_{p,b}(t) \quad (8)$$

where, $SC_{p,b}(t)$ is a subcarrier which is represented as,

$$SC_{p,b}(t) = sgn\big(\sin\big(2\pi f_{p,b}t\big)\big) \quad (9)$$

where, $f_{p,b}$ is a subcarrier frequency which is computed as $f_{p,b}(Hz) = m_3 * 1.023 * 10^6$.

Multiplexed component (24) is derived using the above BOC components,assuming the perfect time synchronization between above BOC components, is given by,

$$S_{d,b}(t) = S_{d,a}(t)S_{p,a}(t)S_{p,b}(t) \quad (10)$$

Equation (10) is expanded using the equation (2), equation (5) and equation (8) which is given as,

$$S_{d,b}(t) = C_d(t)d(t)SC_{d,a}(t)C_p(t)SC_{p,a}(t)C_p(t)SC_{p,b}(t) \quad (11)$$

Equation (11) is further expanded using equation (4), equation (7) and equation (9), assuming the perfect time synchronization between $S_{d,a}(t)$, $S_{p,a}(t)$ and $S_{p,b}(t)$, which is rewritten as,

$$S_{d,b}(t) = C_d(t)d(t)SC_{d,b}(t) \quad (12)$$

where, $SC_{d,b}(t)$ is a subcarrier which is represented as,

$$SC_{d,b}(t) = sgn\left(\sin\left(2\pi f_{d,b}t\right)\right) \quad (13)$$

where, $f_{d,b}$ is a subcarrier frequency which is computed as $f_{d,b}(Hz) = m_3 * 1.023 * 10^6$.

The derived $S_{d,b}(t)$ component is a desired data signal with BOC(m_3, m_2) modulation assuming the perfect time synchronization between $S_{d,a}(t)$, $S_{p,a}(t)$, and $S_{p,a}(t)$ components. The perfect time synchronization between $S_{d,a}(t)$, $S_{p,a}(t)$, and $S_{p,a}(t)$ componentsis also useful to generate the constant envelope SBOC modulation signal during the multiplexing of the $S_{d,a}(t)$, $S_{d,b}(t)S_{p,a}(t)$, and $S_{p,a}(t)$ components.

Furthermore, any one of the BOC component from $S_{d,a}(t)$, $S_{d,b}(t)S_{p,a}(t)$, and $S_{p,a}(t)$ components is generated by multiplexing the other three BOC components is generated as presented in FIG. 1. BOC(m_1, m_2) modulation component of data signal (23), BOC(m_3, m_2) modulation component of data signal (24), BOC(m_1, m_4) modulation component of pilot signal (25) and BOC(m_3, m_4) modulation component of pilot signal (26) are multiplexed (22) to generate the SBOC modulation signal (27), in accordance with an exemplary embodiment of the present invention. Moreover, to generate the SBOC modulation signal which is interoperable with other L1 band satellite navigation signals like TMBOC, CBOC and QMBOC modulated signals, values of m_1, m_2, m_3 and m_4 are selected as 1, 1, 6 and 1 respectively. So, data signal and pilot signals of SBOC signal have two BOC(1, 1) and BOC(6, 1) modulation components.

One of the signal generators (12, 16) is a data channel ranging code generator or a pilot signal ranging code generator. Further, the generated first and second signals are having at least two components.

In one of the embodiment the signal generator consisting of three input signal and one output signal. Further, SBOC modulated signal is represented as nonlinear combination of all the three input signals.

Referring to the FIG. 2, the SBOC modulation generation method by generating the desired BOC component of the data signal using available other BOC component of data signal and two BOC components of the pilot signal and synthesizing BOC components of data and pilot signals for spread spectrum satellite based navigation system, in accordance with an exemplary embodiment of the present invention. Data signal contains BOC(m_1, m_2) and BOC(m_3, m_2) modulation components and pilot signal contains BOC(m_1, m_4) and BOC(m_3, m_4) modulation components.

Furthermore, the SBOC modulation signal contains the data and pilot spread spectrum modulated signals. Data bits (10) are given to encoder (11) before it is spreaded by multiplying (13) encoded data bits with the output of data channel ranging code generator (12). Output of the data channel ranging code generator (12) is a modulated ranging code with chip rate of m_2*1.023 Mcps. Where, m_2 is an integer number with m_2>0. The spreaded data signal is multiplied (15) by the output of BOC(m_1, m_2) subcarrier generator (14) to generate the BOC(m_1, m_2) modulated data signal (31). The subcarrier frequency of BOC(m_1, m_2) modulation is m_1*1.023 MHz. Output of pilot signal ranging code generator (16) is a modulated ranging code with chip rate of m_4*1.023 Mcps. Pilot signal ranging code is multiplied (18) by the output of the BOC(m_1, m_4) subcarrier generator (17) to generate the BOC(m_1, m_4) modulated pilot signal (32). Pilot signal ranging code is also multiplied (20) by the output of the BOC(m_3, m_4) subcarrier generator (19) to generate the BOC(m_3, m_4) modulated pilot signal (33). The subcarrier frequency of BOC(m_3, m_4) modulation is m_3*1.023 MHz. Where, m_3 is an integer number with m_3>0.BOC(m_1, m_2) modulated data signal (31), BOC(m_1, m_4) modulated pilot signal (32) and BOC(m_3, m_4) modulated pilot signal (33) are multiplied (21) to generate multiplexed component (34). The generated multiplexed component (34) is a desired useful BOC(m_3, m_2) modulated data signal which is used for generating the SBOC modulation signal. BOC(m_1, m_2) component of data signal (31), BOC(m_3, m_2) component of data signal (34), BOC(m1, m4) component of pilot signal (32) and BOC(m_3, m_4) component of pilot signal (33) are described by the equation (2), equation (12), equation (5) and equation (8) respectively.

Referring to FIG. 2, amplitude and phase of the each BOC modulation components of data and pilot signals are selected in such a way that the resultant modulation signal have constant modulus waveform. Constant modulus waveform allows to operate the high power amplifier of the transmit section of the satellite navigation payload in saturation region which enables to transmit signal with high transmit power. This results in increase of received isotropic power (RIP) levels on the ground which improves the overall system performance in terms of code/carrier tracking accuracy, improved data demodulation threshold, improved acquisition/tracking threshold etc.Amplitude of BOC(m_1, m_2) component of data signal is scaled by γ using multiplier (22) and amplitude of generated multiplexed BOC(m_3, m_2) component of data signal is scaled by η using multiplier (23).BOC(m_1, m_2) component of data signal and BOC(m_3, m_2) component of data signal are added (26) in equal or different phase states to generate the composite data signal.Amplitude of BOC(m_1, m_4) component of pilot signal is scaled by α using multiplier (24) and amplitude of generated multiplexed BOC(m_3, m_4) component of pilot signal is scaled by β using multiplier (25). BOC(m_1, m_4) component of pilot signal and BOC(m_3, m_4) component of pilot signal are added (27) in different or equal phase states to generate the composite pilot signal.Data signal and pilot signal are quadrature multiplexed to generate the constant modulus waveform. Pilot signal is phase shifted (29) by 0^o or 90^o before adding (30) with data signal which is phase shifted (29) by 90^o or 0^o to generate the SBOC modulated signal (35). The complex envelope of the SBOC modulation signal is defined as,

$$S(t) = \left[\alpha S_{p,a}(t) \mp \beta S_{p,b}(t)\right] + j\left[\gamma S_{d,a}(t) \pm \eta S_{d,b}(t)\right] or$$
$$= \left[\gamma S_{d,a}(t) \pm \eta S_{d,b}(t)\right] + j\left[\alpha S_{p,a}(t) \mp \beta S_{p,b}(t)\right] (14)$$

where, α, β, γ, η are constants with 0 < {α, β, γ, η} < 1 condition. Phase state assignments of BOC(m_3, m_2) modulation component of data signal and BOC(m_3, m_4) pilot signals based on equation (14) is given in Table (1).

Table 1 – Phase stateassignment of BOC(m_3, m_2) modulation and BOC(m_3, m_4) modulation components

Signals / Case	$S_{d,b}(t)$	$S_{p,b}(t)$
1	+	-

2	-	+

To generate the constant modulus signal, {α, β, γ, η} constants are selected with following necessary conditions:

$$\alpha^2 + \beta^2 + \gamma^2 + \eta^2 = 1 \quad (15)$$

$$\alpha\beta = \gamma\eta \quad (16)$$

To generate the SBOC modulation signal (35) which meets the interoperability criteria with other L1 band signals of satellite navigation system, values of m_1, m_2, m_3 and m_4 are selected as 1, 1, 6 and 1 respectively. So, data signal and pilot signals of SBOC modulation signal (35) have two BOC(1, 1) and BOC(6, 1) modulation components.Generating the SBOC modulation signal (35) which meets PSD levels of MBOC(6, 1, 1/11) signal as given in equation (1) requires following additional conditions while selecting the amplitude of the each BOC components of data and pilot signals.

$$\alpha^2 + \gamma^2 = \frac{10}{11} \quad (17)$$

$$\beta^2 + \eta^2 = \frac{1}{11} \quad (18)$$

Referring to the FIG. 2, selection of amplitude of each BOC components of data and pilot signals using equation (15), equation (16), equation (17), and equation (18) along with selection of phasing of BOC(6, 1) modulation component of Data and Pilot signals according to Table (1) generates the SBOC modulation signal (35) which meets PSD levels of MBOC(6, 1, 1/11) while maintaining constant modulus waveform.

In one of the embodiment the generated first and second signals are having different amplitude proportions and different phase states.

Referring to the FIG. 3, in alternate embodiments, other SBOC modulation generation method by generating individual BOC(m_1, m_2) and BOC(m_3, m_2)modulation components of data signal and BOC(m_1, m_4) and BOC(m_3, m_4) modulation components of pilot signal and synthesizing BOC components of data and pilot signals for spread spectrum satellite based navigation system, in accordance with an exemplary embodiment of the present invention. Data signal contains BOC(m_1, m_2) and BOC(m_3, m_2) modulation components and pilot signal containsBOC(m_1, m_4) and BOC(m_3, m_4) modulation components. SBOC modulation signal contains the data and pilot spread spectrum modulated signals. Data bits (10) are given to encoder (11) before it is spreaded by multiplying (13) encoded data bits with the output of

data channel ranging code generator (12). Output of the data channel ranging code generator (12) is a modulated ranging code with chip rate of m_2*1.023 Mcps. Where, m_2 is an integer number with m_2>0. The spreaded data signal is multiplied (15) by the output of BOC(m_1, m_2) subcarrier generator (14) to generate the BOC(m_1, m_2) modulated data signal (32). The subcarrier frequency of BOC(m_1, m_2) modulation is m_1*1.023 MHz. Output of the spreaded encoded data bits with ranging code is multiplied (21) by the output of the BOC(m_3, m_2) subcarrier generator (31) to generate BOC(m_3, m_2) modulated data signal (35). The subcarrier frequency of BOC(m_3, m_2) modulation is m_3*1.023 MHz. Output of pilot signal ranging code generator (16) is a modulated ranging code with chip rate of m_4*1.023 Mcps. Pilot signal ranging code is multiplied (18) by the output of the BOC(m_1, m_4) subcarrier generator (17) to generate the BOC(m_1, m_4) modulated pilot signal (33). Pilot signal ranging code is also multiplied (20) by the output of the BOC(m_3, m_4) subcarrier generator (19) to generate the BOC(m_3, m_4) modulated pilot signal (34). BOC(m_1, m_2) component of data signal (32), BOC(m_3, m_2) component of data signal (35), BOC(m_1, m_4) component of pilot signal (33) and BOC(m_3, m_4) component of pilot signal (34) are described by the equation (2), equation (12), equation (5) and equation (8) respectively.

Furthermore, assuming the perfect time synchronization between BOC modulation components of data and pilot signal, amplitude and phase of the each BOC modulation components of data and pilot signals are selected in such a way that the resultant modulation signal have constant modulus waveform. Amplitude of BOC(m_1, m_2) component of data signal (32) is scaled by γ using multiplier (22) and amplitude of generated BOC(m_3, m_2) component of data signal (35) is scaled by η using multiplier (23). BOC(m_1, m_2) component of data signal and BOC(m_3, m_2) component of data signal are added (26) in equal or different phase states to generate the composite data signal. Amplitude of BOC(m_1, m_4) component of pilot signal is scaled by α using multiplier (24) and amplitude of generated multiplexed BOC(m_3, m_4) component of pilot signal is scaled by β using multiplier (25). BOC(m_1, m_4) component of pilot signal and BOC(m_3, m_4) component of pilot signal are added (27) in different or equal phase states to generate the composite pilot signal. Data signal and pilot signal are quadrature multiplexed to generate the constant modulus waveform. Pilot signal is phase shifted (29) by 0^o or 90^o before adding (30) with data signal which is phase shifted (29) by 90^o or 0^o to generate the SBOC modulated signal (36). The complex envelope of the SBOC modulation signal (36) is defined in equation (14).Assuming

m_1, m_2, m_3 and m_4 are selected as 1, 1, 6 and 1 respectively, {α, β, γ, η} constants are selected with necessary conditions given in equation (15), equation (16), equation (17) and equation (18) along with selection of phasing of BOC(6, 1) modulation component of Data and Pilot signals according to Table (1) generates the SBOC modulation signal which meets PSD levels of MBOC(6, 1, 1/11) while maintaining constant modulus waveform.

Referring to the FIG. 4, the SBOC modulation generation method for spread spectrum satellite based navigation system is also applied at the navigation receiver to track and demodulate the navigation signals, in accordance with an exemplary embodiment of the present invention. SBOC modulation signal transmitted by satellite navigation system which is received by an antenna (10) at receiver end.Output of receive antenna (10) is fed to the RF front end (11) of the receiver which is consisting of the LNA, filters, and frequency converter etc. Signal from RF front end (11) is given to analog to digital converter (12) to process the signal for range measurements and position fixing. Digitized signal is multiplied (13) by SBOC modulation generator (15) output as defined in equation (14) before processing it for multi-channel code/carrier tracking loops & correlator and decoding of navigation data bits.

Referring to the FIG. 5, the example waveform of modulated navigation encoded data bits (10) used in generating the two BOC components of data signal for generating the SBOC modulated signal is shown, in accordance with an exemplary embodiment of the present invention. T_b is the bit duration of the encoded navigation data bits.

Referring to the FIG. 6, the example waveform of modulated ranging code chips (10) used in generating the BOC(m_1, m_4) and BOC(m_3, m_4) components of pilot signal for generating the SBOC modulated signal is shown, in accordance with an exemplary embodiment of the present invention.The presented waveform of modulated ranging code also includes the secondary overlay code.

Referring to the FIG. 7, the example waveform of modulated ranging code chips (10) used in generating the BOC(m_1, m_2) and BOC(m_3, m_2) components of data signal for generating the SBOC modulated signal is shown, in accordance with an exemplary embodiment of the present invention.

Referring to the FIG. 8, the example waveform of subcarrier (10) of BOC(m_1, m_2) modulated data signal and BOC(m_1, m_4) modulated pilot signal for generating the SBOC modulated signal is shown, in accordance with an exemplary embodiment of the present

invention. It is a subcarrier of sine BOC modulation signal which is defined in equation (4) and equation (7).

Referring to the FIG. 9, the example waveform of subcarrier (10) of BOC(m_3, m_2) modulated data signal and BOC(m_3, m_4) modulated pilot signal for generating the SBOC modulated signal is shown, in accordance with an exemplary embodiment of the present invention. It is a subcarrier of sine BOC modulation signal which is defined in equation (9) and equation (10).

Referring to the FIG. 10, assuming m_1, m_2, m_3 and m_4 are selected as 1, 1, 6 and 1 respectively, the example waveforms of BOC(1, 1) modulated component (10) of pilot signal and BOC(6, 1) modulated component (11) ofpilot signal, BOC(1, 1) modulated component (12) of data signal and multiplexed component which is a desired BOC(6, 1) modulated component (13) of data signal which is generated using equation (10) and as per the signal flow given in FIG. 1, for generating the SBOC modulated signal are shown, in accordance with an exemplary embodiment of the present invention. Assuming the perfect time synchronization between BOC(1, 1) modulation component (10) of pilot signal, BOC(6, 1) modulation component (11) of pilot signal and BOC(1, 1) modulation component (12) of data signal, generated multiplexed component (13) using these three BOC modulation component, to generate the constant modulus waveform, results in desired BOC(6, 1) modulation component (13) of data signal. Both data and pilot signals have two BOC modulation components which provide the feasibility to generate the modulation signal interoperable with MBOC modulation while maintaining the constant modulus waveform. Synthesizing all the four components of both signals in various proportions of amplitude as per the equation (15), equation (16), equation (17), and equation (18) and phase states as per the Table (1) results in modulated signal that has PSD levels same as MBOC(6, 1, 1/11) modulation along with constant modulus waveform.

Referring to the FIG. 11, the example constellation (10) of constant envelope SBOC modulated signal which meets the MBOC PSD levels is shown for $\{\alpha = \sqrt{7/11},\ \beta = \sqrt{3/110},\ \gamma = \sqrt{3/11},\ \eta = \sqrt{7/110}\}$ amplitude constants with phase state of BOC(6, 1) modulation component of data and pilot signals as per the case-1 given in Table (1), in accordance with an exemplary embodiment of the present invention. PSD of the generated

data signal of SBOC modulation, pilot signal of SBOC modulation and composite SBOC modulation signal are given in equation (19), equation (20) and equation (21) respectively.

$$G_{Pilot}(f) = \alpha^2 G_{BOC(1,1)}(f) + \beta^2 G_{BOC(6,1)}(f) \quad (19)$$

$$G_{data}(f) = \gamma^2 G_{BOC(1,1)}(f) + \eta^2 G_{BOC(6,1)}(f) \quad (20)$$

$$G_{SBOC}(f) = G_{data}(f) + G_{pilot}(f) \quad (21)$$

where, $G_{BOC(1,1)}(f)$ and $G_{BOC(6,1)}(f)$ are PSDs of BOC(1, 1) and BOC(6, 1) modulation signals respectively. Equation (21) is rewritten as,

$$G_{SBOC}(f) = (\alpha^2 + \gamma^2) G_{BOC(1,1)}(f) + (\beta^2 + \eta^2) G_{BOC(6,1)}(f) \quad (22)$$

Referring to the FIG. 12, PSD of the example SBOC modulated signal (10),generated using the equation (14) which meets the PSD levels of MBOC modulation for $\{\alpha = \sqrt{7/11}, \beta = \sqrt{3/110}, \gamma = \sqrt{3/11}, \eta = \sqrt{7/110}\}$ amplitude constants with phase state of BOC(6, 1) modulation component of data and pilot signals as per the case-1 given in Table (1), is shown, in accordance with an exemplary embodiment of the present invention. Equation (22) is rewritten with $\{\alpha = \sqrt{7/11}, \beta = \sqrt{3/110}, \gamma = \sqrt{3/11}, \eta = \sqrt{7/110}\}$ amplitude constants as,

$$G_{SBOC}(f) = \frac{10}{11} G_{BOC(1,1)}(f) + \frac{1}{11} G_{BOC(6,1)}(f) \quad (23)$$

An important criterion for analysing the performance of the navigation modulation signal is its performance under multipath environment. Hence, optimum selection of the values of amplitude constants with different phase states is dependent on the performance comparison of SBOC modulation with other MBOC modulations under multipath environment while maintaining the constant modulus waveform. Typically, in L1 band navigation satellite signals, time synchronization and ranging is carried out through pilot signal only. Therefore, it becomes necessary to improve the performance of the SBOC pilot signal compared to other MBOC modulation signals and optimize the values amplitude constant and phase states of BOC(6, 1) modulation component of data and pilot signals accordingly.

The foregoing descriptions of exemplary embodiments of the present invention have been presented for purposes of illustration and description. They are not intended to be exhaustive or to limit the invention to the precise forms disclosed, and obviously many modifications and variations are possible in light of the above teaching. The exemplary embodiment was chosen and described in order to best explain the principles of the

invention and its practical application, to thereby enable others skilled in the art to best utilize the invention and various embodiments with various modifications as are suited to the particular use contemplated. It is understood that various omissions, substitutions of equivalents are contemplated as circumstance may suggest or render expedient, but is intended to cover the application or implementation without departing from the spirit or scope of the claims of the present invention.

We Claim:

1. A method of generating a spreading Synthesized Binary Offset Carrier (SBOC) modulated signal, the method comprising:

   generating first and second signal using first and second signal generators (12, 16);

   modulating first and second generated signals with signal generated from at least a subcarrier generators (14, 17, 19);

   generating multiplexed modulated signal (24), wherein the generation is based on multiplexing (21) of sub modulated signals (23, 25, 26) generated from modulating the first signal generator (12) and the second signal generator (16) with signal generated from at least a subcarrier generators (14, 17, 19); and

   synthesizing the multiplexed modulated signal (24) and the sub modulated signals (23, 25, 26) using a unit (22) to generate SBOC modulated signal.

2. The method, as claimed in claim 1, wherein first signal is multiplied (15) by an output of Binary Offset Carrier (BOC) (m_1, m_2) subcarrier generator (14) to generate the BOC (m_1, m_2) sub modulated data signal (23).

3. The method, as claimed in claim 1, wherein second signal is multiplied (18) by an output of BOC (m_1, m_4) subcarrier generator (17) to generate the BOC (m_1, m_4) sub modulated pilot signal (25).

4. The method, as claimed in claim 3, wherein the second signal is further multiplied (20) by the output of the BOC (m_3, m_4) subcarrier generator (19) to generate the BOC (m_3, m_4) second sub modulated pilot signal (26).

5. The method, as claimed in claims 1 to 4, wherein sub modulated data signal (23), sub modulated pilot signal (25) and second sub modulated pilot signal (26) are multiplied (21) to generate multiplexed signal (24), and

wherein the multiplexed signal (24) is a second sub modulated data signal.

6. The method, as claimed in claims 1 to 5, wherein sub modulated data signal (23), sub modulated pilot signal (25), second sub modulated pilot signal (26) and sub modulated multiplexed signal (24) are synthesized to generate the SBOC modulation signal (27).

7. The method, as claimed in claim 1, wherein the generated first and second signals is having at least two sub modulated signals.

8. The method, as claimed in claim 1, wherein one of the signal generators (12, 16) is a data channel ranging code generator or a pilot channel ranging code generator, and

wherein, the data channel ranging code generator and pilot channel ranging code generator are orthogonal pseudo-random noise (PRN) codes.

9. The method, as claimed in claim 1, wherein the synthesized modulated signal generator consisting of three input signals and one output synthesized modulated signal.

10. The method, as claimed in claim 1, wherein the generated first and second signals are having different amplitude proportions and different phase states.

11. The method, as claimed in claims 1, wherein SBOC modulated signal is represented as nonlinear combination of all the three input signals.

12. The method, as claimed in claim 1, wherein the first signal is derived by aggregating first sub modulated signal of same signal and second sub modulated signal of same signal which is derived by multiplexing the other sub modulated signal of the same signal and both sub modulated signals of other signal.

13. The method, as claimed in claim 1, wherein the second signal is derived by aggregating first sub modulated signal of same signal and second sub modulated signal of same signal.

14. The method, as claimed in claim 1, wherein synthesizing all the sub modulated signals of first and second signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal having constant modulus waveform.

15. The method, as claimed in claims 12 to 14, wherein synthesizing all the sub modulated signals of first and second signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal meeting desired Power Spectral Density (PSD) level.

16. The method, as claimed in claims 12 to 15, wherein synthesizing all the sub modulated signals of first and second signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal having constant modulus waveform while meeting desired PSD level.

17. The method, as claimed in claim 12 to 16, wherein generated SBOC signal comprises two orthogonal PRN codes.

18. The method, as claimed in claim 12 to 17, wherein generated SBOC signal comprises of data and pilot signals; and

wherein each signal consists of two sub modulated signals.

19. The method, as claimed in claim 12 to 18, wherein synthesizing all the sub modulated signals of both signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal having constant modulus waveform while meeting signal PSD levels of multiplexed binary offset carrier (MBOC)(6, 1, 1/11) modulation.

20. The method, as claimed in claims 12 to 19, wherein

the first signal is derived from the first and second sub modulated signals of the first signal;

the second signal is derived from the first and second sub modulated signals of the second signal;

synthesizing all the sub modulated signals of both signals in different amplitude proportions and phase states that results in a spreading SBOC modulation signal meeting PSD levels of MBOC (6, 1, 1/11) modulation while maintaining constant modulus waveform.

21. A system for generating a spreading Synthesized Binary Offset Carrier (SBOC) modulated signal, the system comprises:

a first signal generator (12) for generating first signal;

a second signal generator (16) for generating second signal;

at least a subcarrier generator (14, 17, 19) connected with the signal generated from the first signal generator (12) or the second signal generator (16), configured to modulate the first generated signal and the second generated signal;

a plurality of electrical units configured to generate multiplexed modulated signal (24), wherein the generation is based on multiplexing (21) of sub modulated signals (23, 25, 26) generated from modulating first signal generator (12) and the second signal generator (16) with signal generated from at least a subcarrier generators (14, 17, 19); and

a unit (22), for synthesizing the multiplexed modulated signal (24) and sub modulated signals (23, 25, 26) to generate SBOC modulated signal.

22. The system, as claimed in claim 21, wherein the first signal is multiplied (15) by an output of Binary Offset Carrier (BOC) (m_1, m_2) subcarrier generator (14) to generate the BOC (m_1, m_2) sub modulated data signal (23).

23. The system, as claimed in claim 21, wherein the second signal is multiplied (18) by an output of BOC (m_1, m_4) subcarrier generator (17) to generate the BOC (m_1, m_4) sub modulated pilot signal (25).

24. The system, as claimed in claim 23, wherein the second signal is further multiplied (20) by the output of the BOC (m_3, m_4) subcarrier generator (19) to generate the BOC (m_3, m_4) second sub modulated pilot signal (26).

25. The system, as claimed in claims 21 to 24, wherein sub modulated data signal (23), sub modulated pilot signal (25) and second sub modulated pilot signal (26) are multiplied (21) to generate multiplexed signal (24), and

wherein the multiplexed signal (24) is a second sub modulated data signal.

26. The system, as claimed in claims 21 to 25, wherein sub modulated data signal (23), sub modulated pilot signal (25), second sub modulated pilot signal (26) and sub modulated multiplexed signal (24) are synthesized to generate the SBOC modulation signal (27).

27. The system, as claimed in claims 21 to 26, wherein the generated first and second signals is having at least two sub modulated signals.

28. The system, as claimed in claims 21 to 27, wherein one of the signal generators (12, 16) is a data channel ranging code generator or a pilot channel ranging code generator, and

wherein the data channel ranging code generator and pilot channel ranging code generator are orthogonal PRN codes.

29. The system, as claimed in claim 21, wherein the synthesized modulated signal generator consisting of three input signals and one output synthesized modulated signal.

30. The system, as claimed in claim 21, wherein the generated first and second signals are having different amplitude proportions and different phase states.

31. The system, as claimed in claims 21, wherein the generated SBOC modulated signal is represented as nonlinear combination of all the three input signals.

32. The system, as claimed in claim 21, wherein the first signal is derived by aggregating first sub modulated signal of same signal and second sub modulated signal of same signal which is derived by multiplexing the other sub modulated signal of the same signal and both sub modulated signals of other signal.

33. The system, as claimed in claim 21, wherein the second signal is derived by aggregating first sub modulated signal of same signal and second sub modulated signal of same signal.

34. The system, as claimed in claims 32 and 33, wherein synthesizing all the sub modulated signals of first and second signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal having constant modulus waveform.

35. The system, as claimed in claims 32 to 34, wherein synthesizing all the sub modulated signals of first and second signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal meeting desired PSD level.

36. The system, as claimed in claims 32 to 35 wherein synthesizing all the sub modulated signals of first and second signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal having constant modulus waveform while meeting desired PSD level.

37. The system, as claimed in claim 32 to 36, wherein generated SBOC signal that comprises of two orthogonal PRN codes.

38. The system, as claimed in claim 32 to 37, wherein generated SBOC signal comprises of data and pilot signals, and

wherein each signal consists of two sub modulated signals.

39. The system, as claimed in claim 32 to 38, wherein synthesizing all the sub modulated signals of both signals in different amplitude proportions and different phase states that results in a spreading SBOC modulation signal having constant modulus waveform while meeting signal PSD level of MBOC (6, 1, 1/11) modulation.

40. A satellite navigation system comprises system for generating a spreading Synthesized Binary Offset Carrier (SBOC) modulated signal as claimed in claims 21 to 39.

Dated this 29 day of May 2020

- Digitally signed -

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Abstract

METHOD FOR GENERATING MODULATION SIGNALS FOR A SATELLITE NAVIGATION SYSTEM

The present invention discloses a method of generating a spreading Synthesized Binary Offset Carrier (SBOC) modulated signal. The method comprising: generating first and second signal using first and second signal generators (12, 16), modulating first or second generated signals with signal generated from at least a subcarrier generators (14, 17, 19). Further, synthesizing modulated data signals, wherein said synthesis is based on the modulated signal generated by a connection between the at least one subcarrier generator (14, 17, 19) with the first signal generator (12) or the second signal generator (16). Furthermore, aggregating said synthesized modulated data signals using a unit (22) to generate SBOC modulated signal.

[Fig. 1]